

Rapid and Reliable Damage Proxy Map From InSAR Coherence

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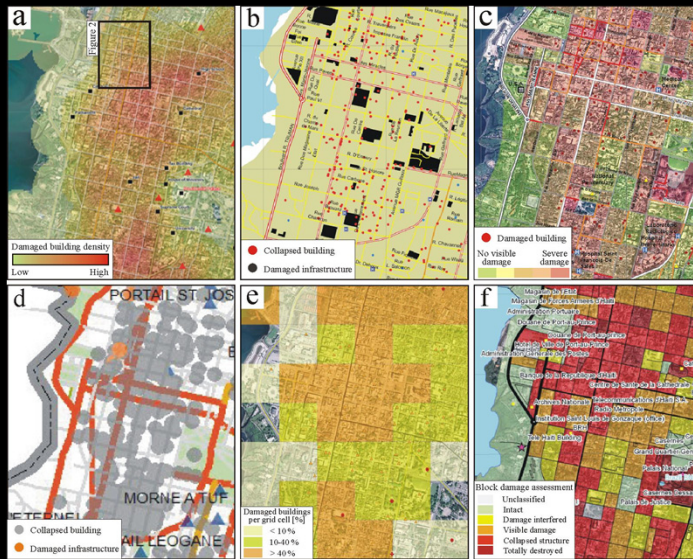
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2. California Institute of Technology, Pasadena, CA, USA



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Damage Assessment Effort in Haiti



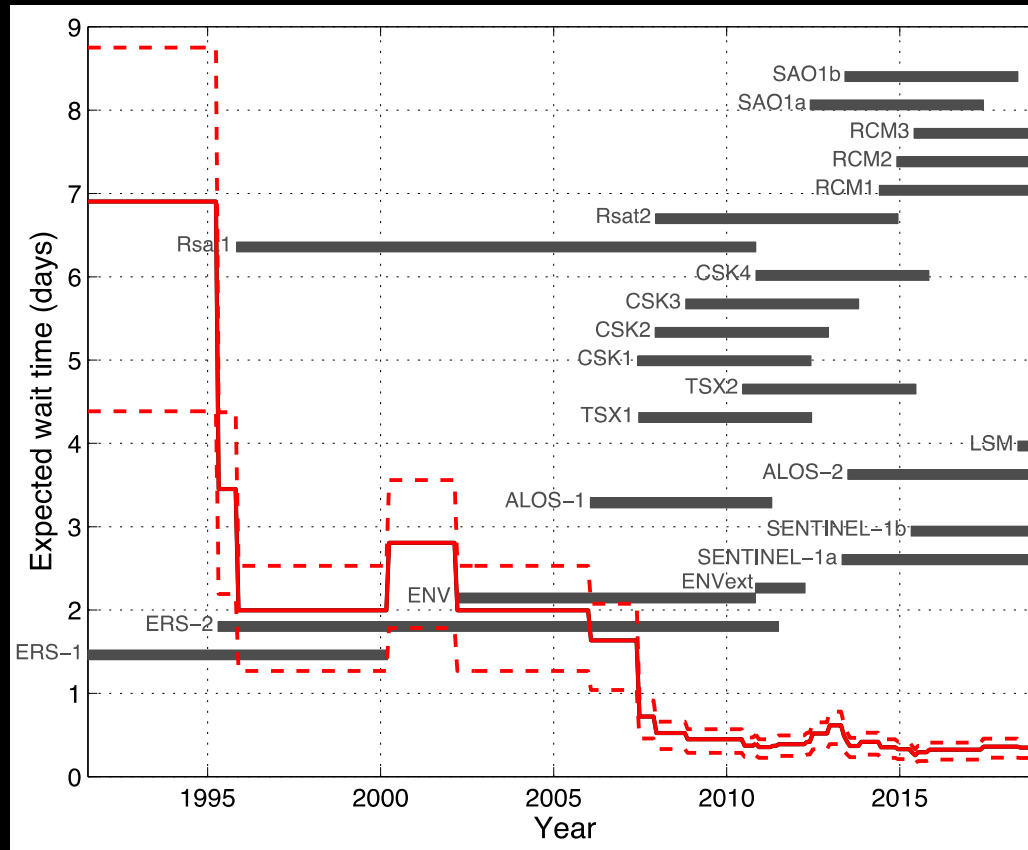
10,000 NGOs were estimated to be active.

More than 2000 damage maps for Haiti catalogued by Reliefweb.

Collaborative damage mapping results based on 50 cm satellite imagery and 15 cm aerial imagery by more than 500 expert volunteers organized by ImageCat for parts of Port-au-Prince.

Despite the superb data quality, only about 63% of the buildings mapped as severely damaged were identified as such.

Data Acquisition Latency (all InSAR missions)



Expected wait time until the first SAR satellite to visit after an event

Ascending + descending orbit

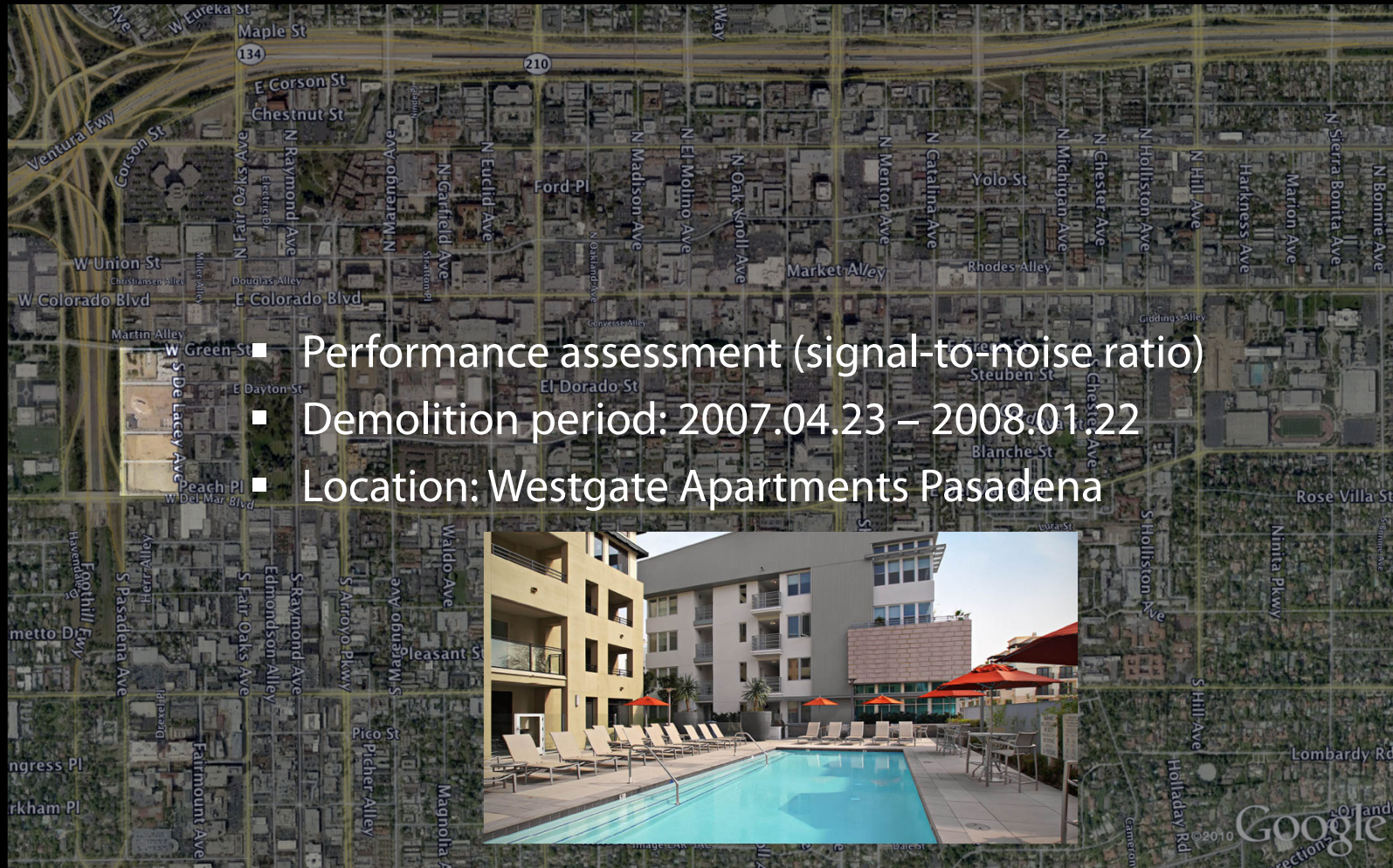
Right-looking mode

Latitude of 38° N/S

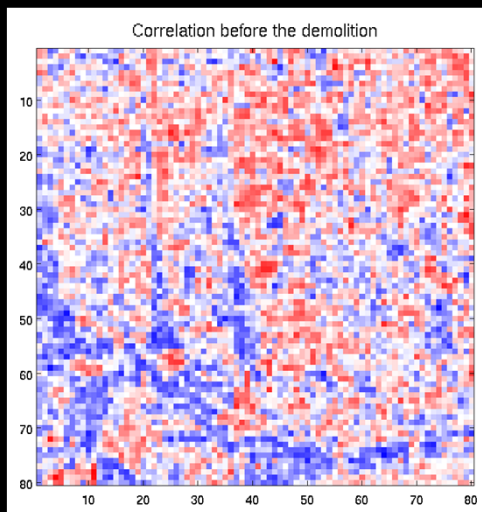
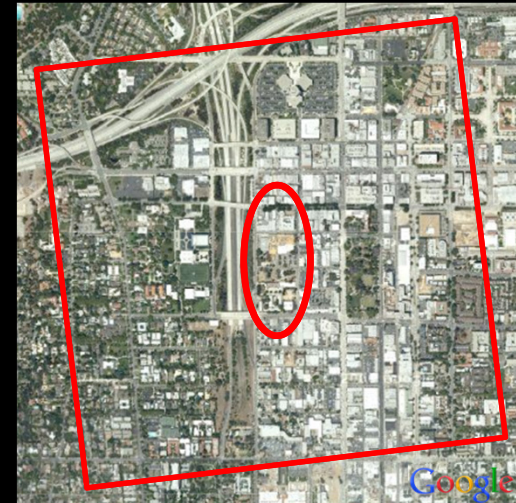
Present: 15 hours

2020: 8 hours

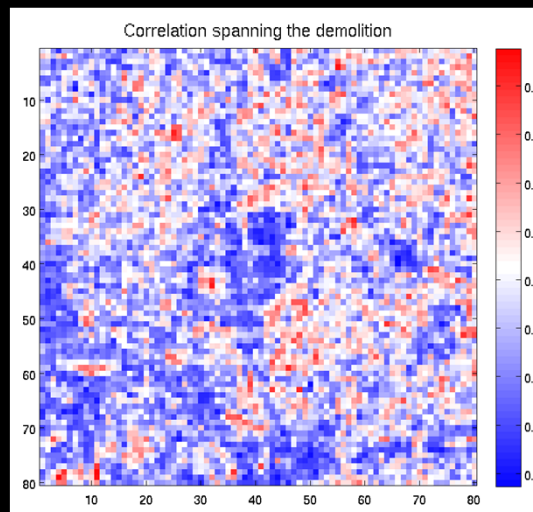
Pasadena Building Demolition Project



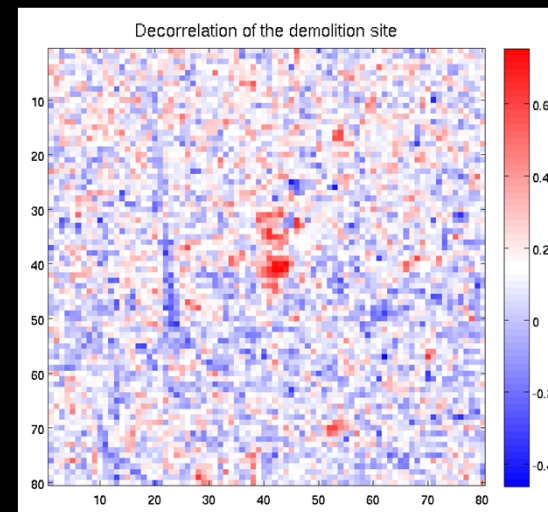
Simple Difference



-

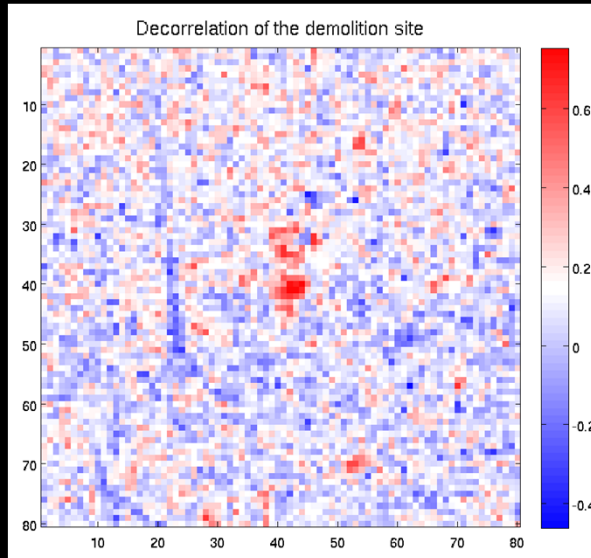


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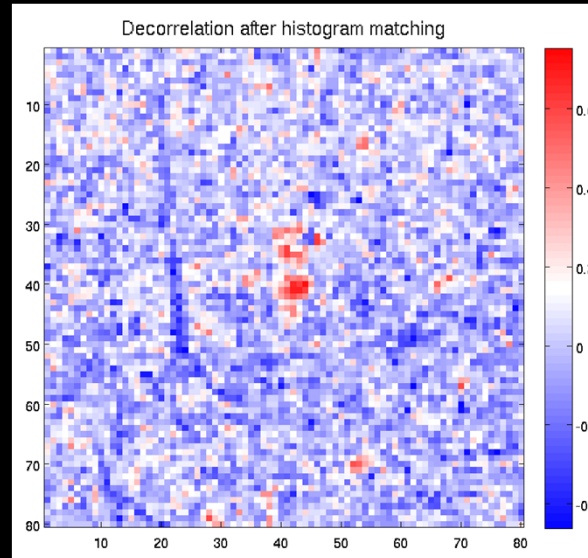


Results

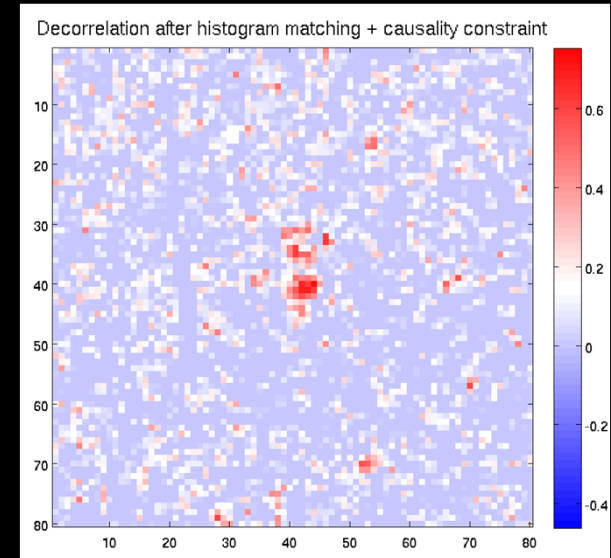
Simple Difference
SNR = 17.3



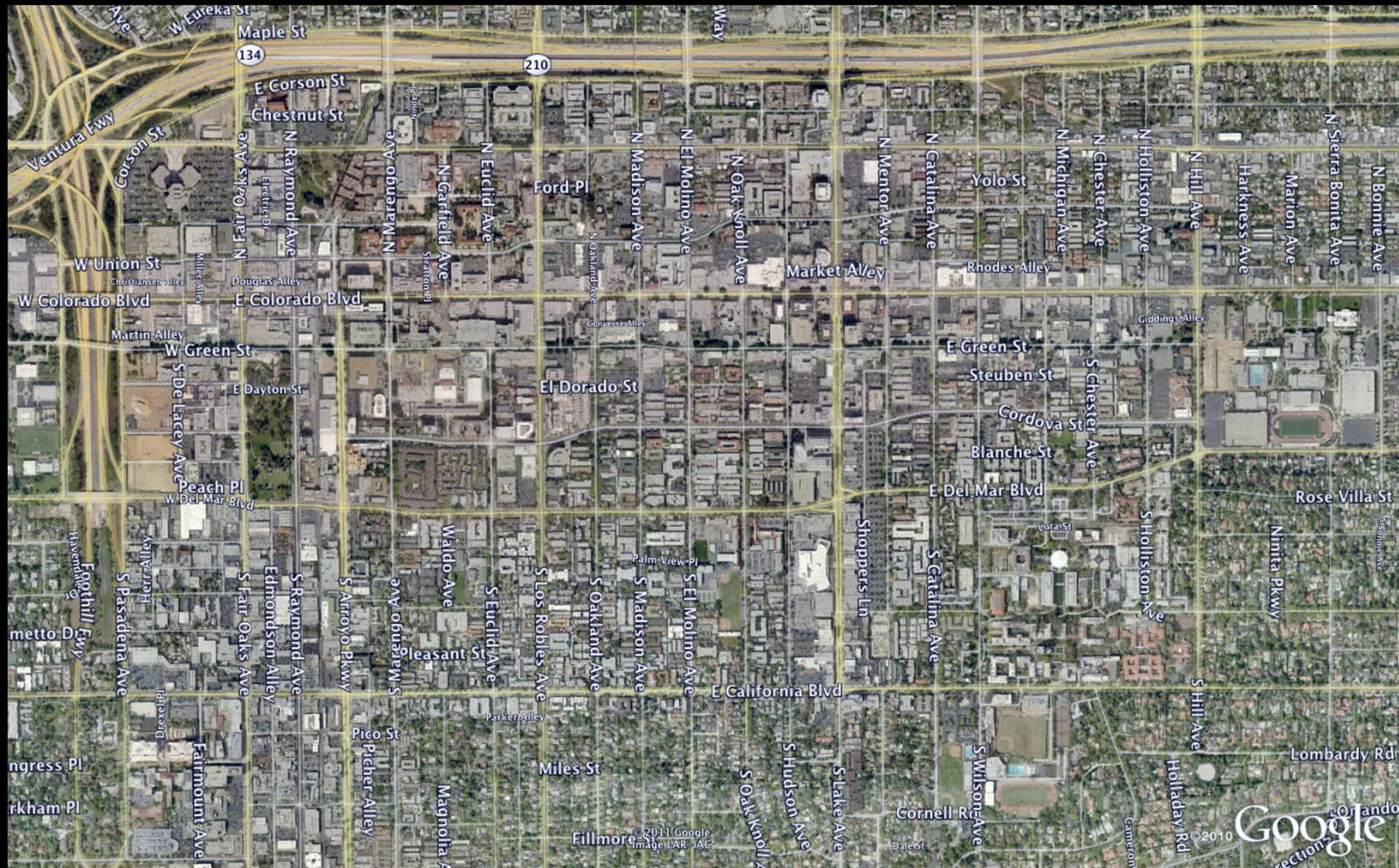
Histogram Matching
SNR = 23.1



Causality Constraint
SNR = 44.6

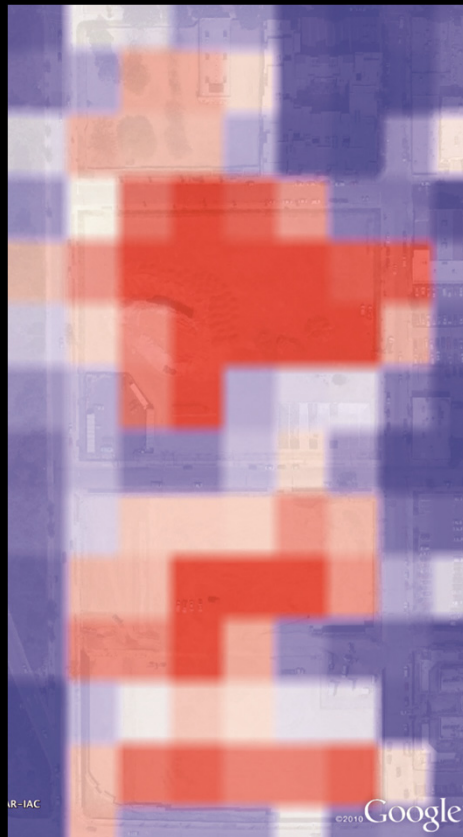


Google Earth Image (2008.01.09)



A Google Map of San Francisco showing three red locations labeled S1, S2, and S3. S1 is located near W Union St and S De La Cruz Ave. S2 is located near E Green St and S Chestnut Ave. S3 is located near S Lake Ave and S Oak Knoll Ave. The map includes street names, a grid, and a copyright notice for 2011 Google.

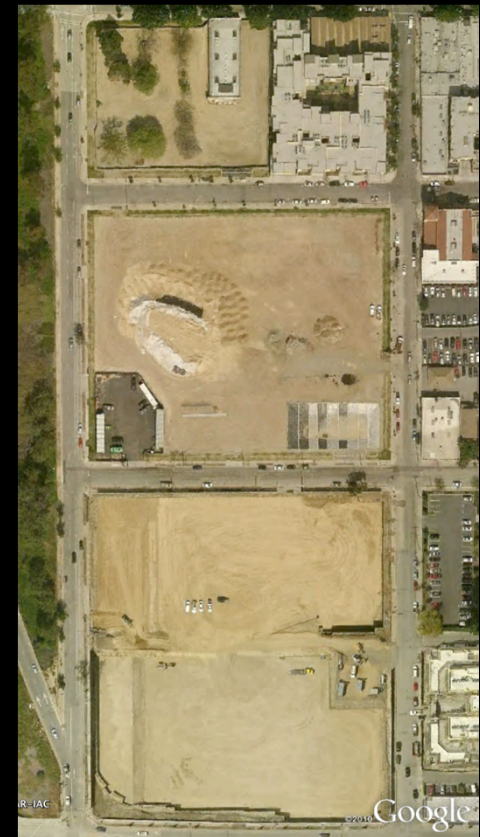
Site 1: Building blocks demolished



DPM

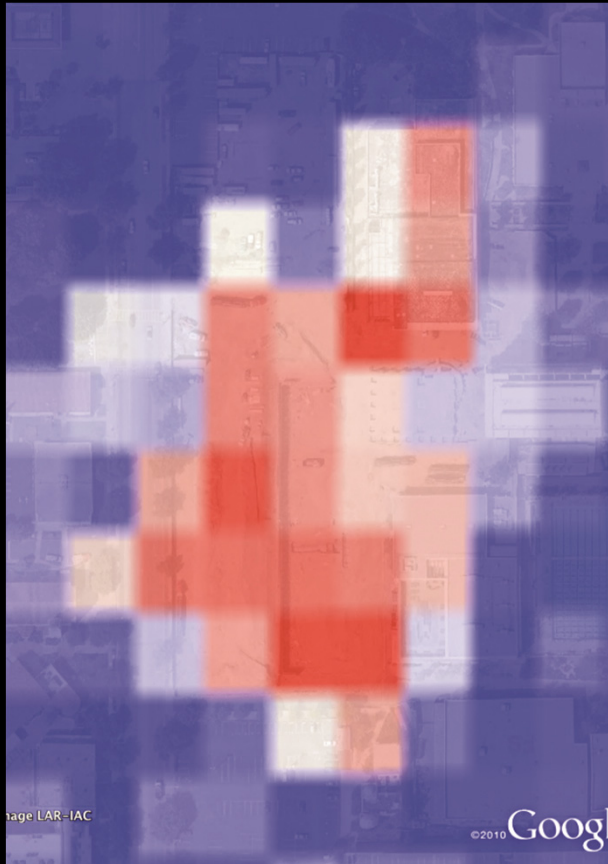


2007.10.23



2008.01.09

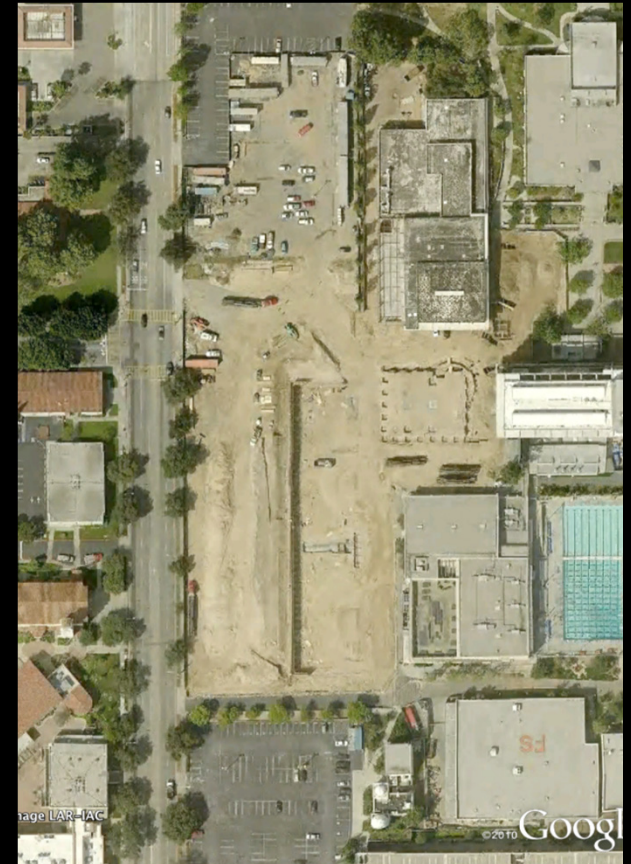
Site 2: Pasadena City College remodeling



DPM

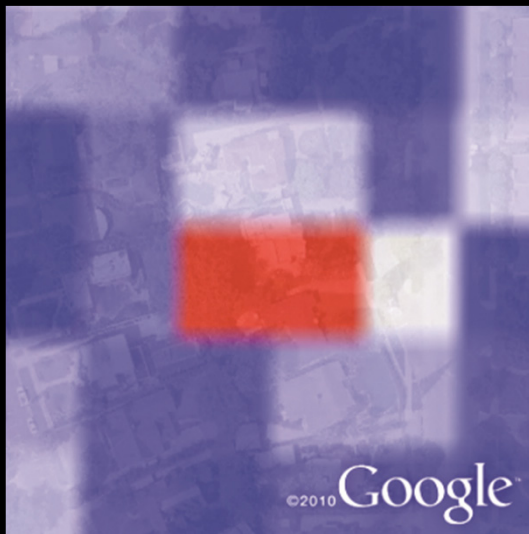


2007.10.23

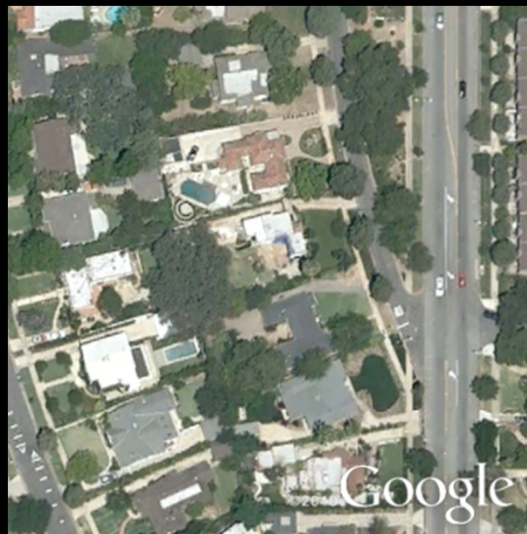


2008.01.09

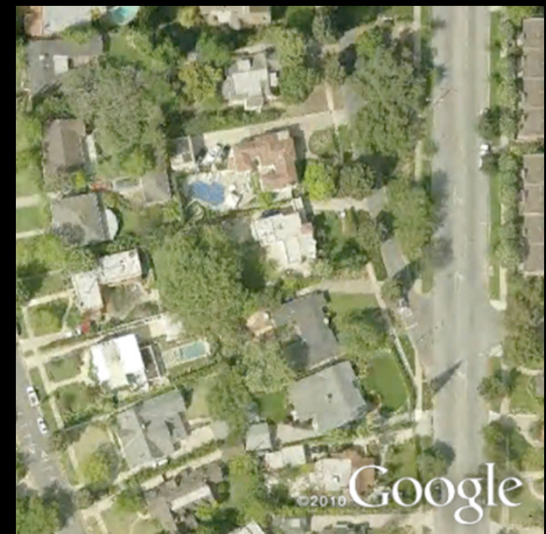
Site 3: Single family house room addition



DPM



2007.10.23



2008.01.09

Christchurch Earthquake

February 22, 2011

Magnitude 6.3

At least 181 people were killed

Peak acceleration: 1.88g

Extensive liquefaction producing
400,000 tons of silt

Estimated cost: US \$12-13 billion

Damage assessment by NZ
government under progress










Ground Truth with Engineering Reports


2010 UCHN EQ - LAND ENGINEERING REPORT					
		EQC Case Number: 2010-000777 Geographic Address: VATES CROSSLAND EARTHQUAKE Claimant Name: J. JOHNS		Significant Risk to Safety: YES NO Engineer's Name: R. GIBNEY Engineer's Email: r.gibney@eqc.co.nz Date: 4/10/2011 Name: [Signature]	
LAND DAMAGE CATEGORY		BLACK	RED	ORANGE	GREEN BLUE
GENERAL:					
Type of Damage	Landslide Storm/flood				
EQC Priority of claims	1 - Home/Land seriously damaged and uninhabitable 2 - Severe Land and Property damaged but habitable 3 - Moderate damage to Home/Land & Habitable 4 - Other damage				
Is this natural Disaster Event?					
Is there an Imminent Risk of Loss?	YES NO				
INSPECTION DATA & DISCUSSION WITH CLAIMANT(S):					
Discussion with Claimant/Occupier? YES NO					
What happened? Claimant's story					
SITE DESCRIPTION (See Site Plan and Cross Section)					
General: NO LAND DAMAGE TO STAIRWAY DRAINAGE TO HOUSE					
LAND - (DAMAGED ACCESS, LAND, & DESTROYED LAND, & RETAINING WALLS, BRIDGES, CULVERTS)					
Type of damage to land	None Landslides Band Bolts Ground Rupture Surface slump rotational slip				
	Lateral Spreading Permanent Settlement Lateral Sliding version cracks (handhole) top-surge other				
Retaining wall damaged?	None No walls damaged other				
Type of damage to retaining walls	Bands rotated/slipping slide settlement				
Location of retaining wall(s)	Within 5m of building within 5m of building other				
Land beneath main access area damaged?	None Within 5m of building other				
Area of land Damage	Entire Site Portion of Site None				
Detailed Areas within 8 m of Damage	Total Site Area: 5.2% AREA (m ²) (only complete table if a portion of site is damaged) Excavated BLACK Elevated - Imminent Risk RED Foundations Inundated - Imminent Risk Excavated ORANGE Elevated - Imminent Risk GREEN Inundated BLUE Excavated - Imminent Risk None EQC Area				
Other supporting assembly					

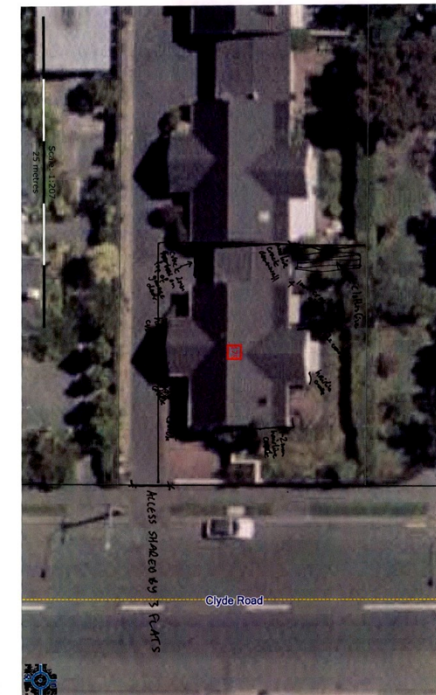
	\$0	\$25K - \$50K	\$50K - \$1M	\$15K - \$50K \$25K - \$1M	\$75K - \$100K \$50K - \$250K	\$100K - \$25K
DWELLING DESCRIPTION (Refer to Plan and Cross Section)						
(General): (not generally req'd)	Single Story, Slab on Grade, Ladderless Roof, Stairs on Grade, Garages Attached, Painted Siding, Cedar Shingles, Ceiling, Siding, Hardwood Floors, Windows, Doors, Walls, Main Entry, Double Windows, Backyard Deck, etc.					
BUILDING DAMAGE - GENERAL						
Has the building been damaged?	YES	NO				
Is the Dwellling at Imminent Risk?	YES	NO				
Estimated Remedial Value*	\$0	\$15K - \$25K	\$25K - \$50K	\$50K - \$75K		
Have any Apurtment structures been damaged?	YES	NO				
Are any Apartment structures at Imminent Risk?	YES	NO				
Have any services within 60 m of dwelling been damaged?	YES	NO				
Are any services within 60 m of dwelling at Imminent Risk?	YES	NO				
DAMAGED DWELLING APURTMENT STRUCTURES & SERVICES (Refer to Plan and Cross Section)						
Dwelling - features damaged:	None window glass other	external wall steps	internal walls foundation/slab	casing roof	door/window frames chimney	
Type of damage to Dwelling:	cracks (walls) damp/moulding	cracks (ceiling) walls all out of vertical	cracks (window glass) crack in slab	cracks (chimney) crack in footing	floor sloping	
Apartment structure(s) damaged:	None	garage/shed	carport	deck	tanks	
What services have been damaged?	water telephone	sewer service structures	drainage D/DOT Know	gas other	electrical None	
GENERAL:						
No damage to walls or exterior surfaces, staining or damage to walls Yes water (minor) CNISD ? Salts of water in ceiling → Gas (LPG/LP) in Car in Box						

EQC - Christchurch Land Engineering Report 2010		(Revision A: 5/10/2010)		Claim No.: 2010/C66731	
Floors and Foundations	<input checked="" type="checkbox"/> Roof Cladding	<input checked="" type="checkbox"/> Wall Cladding			
Timber floor on piles	<input checked="" type="checkbox"/> Light: Iron roof	<input checked="" type="checkbox"/> Light: weatherboard/plywood/stucco etc.			
Timber on internal piles with perimeter concrete footing	<input checked="" type="checkbox"/> Heavy: concrete tiles/clay tiles/slate etc.	<input checked="" type="checkbox"/> Heavy: brick veneer/stone/solid plaster			
<input checked="" type="checkbox"/> Concrete slab on grade					

*** SHALING DAMAGE ONLY ***

Type of Damage	Minor	Sev Mod
Stretching 	0 to 5mm	5 to 10
Hogging 	0 to 20mm	20 to 30
Dishing 	0 to 20mm	20 to 30
Racking/Twisting 	0 to 10mm	10 to 30
Tilting 	0 to 20mm	20 to 30
Discontinuous Foundation 	0 to 10mm	10 to 20
Global Settlement 	0 to 50mm	50 to 100



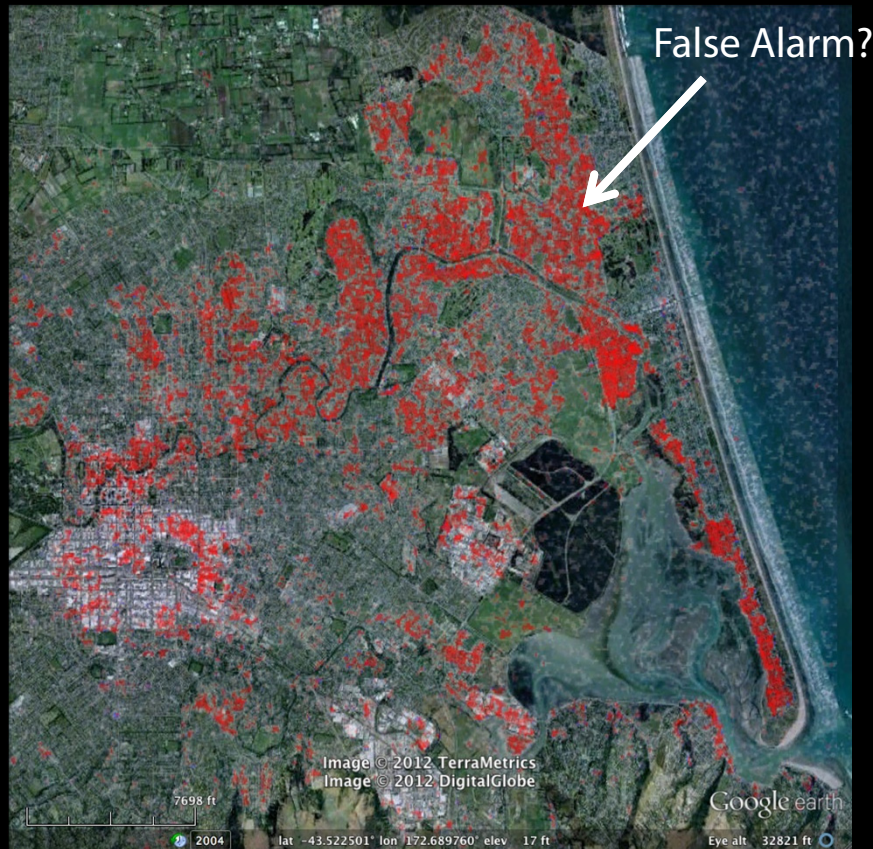


Created by Tonkin & Taylor NZ
for CERA (Christchurch Earthquake Recovery Authority)



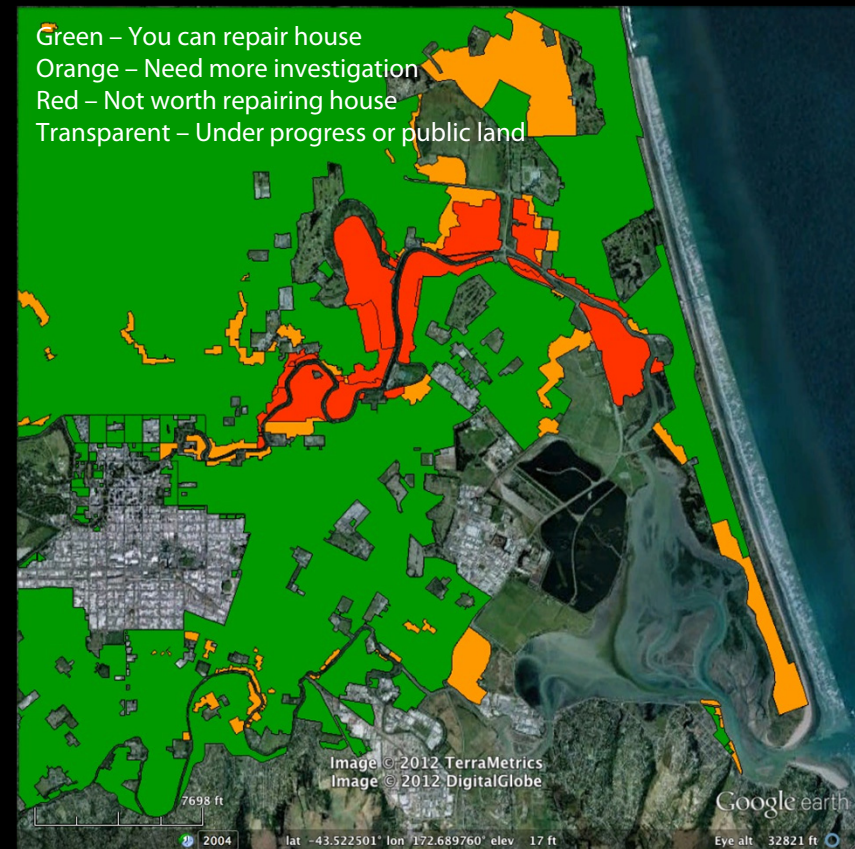
Damage Proxy Map vs Ground Truth

From radar data acquired **3 days** after EQ



Damage Proxy Map (ALOS PALSAR A335):
2010.10.10 – 2011.01.10 – 2011.02.25
Google Earth (GeoEye) Image: 2011.02.26

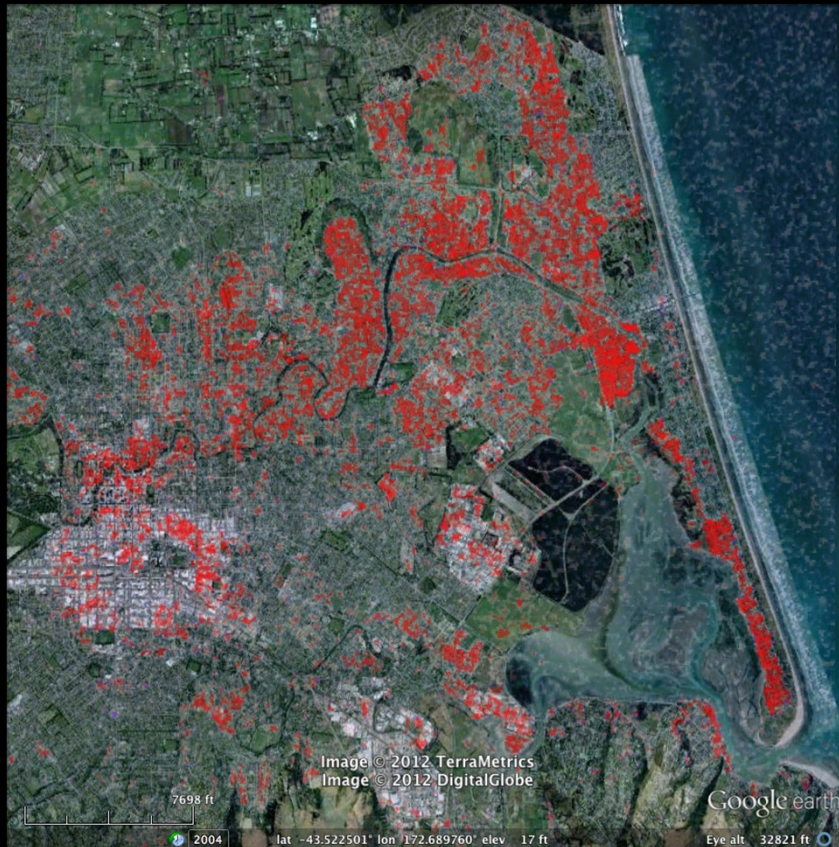
Zone Map first released **4 months** after EQ



2011.06.22 version
Data provided by the New Zealand Government
<http://data.govt.nz>

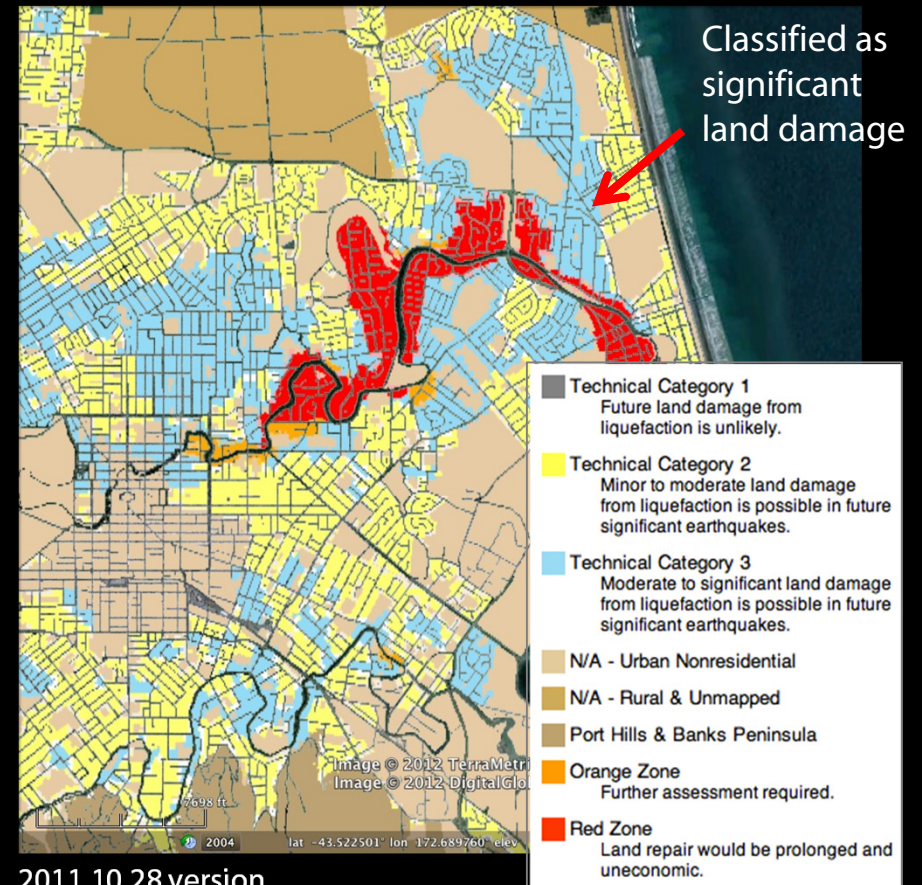
Damage Proxy Map vs Ground Truth

From radar data acquired **3 days** after EQ



Damage Proxy Map (ALOS PALSAR A335):
2010.10.10 – 2011.01.10 – 2011.02.25
Google Earth (GeoEye) Image: 2011.02.26

Technical Classification Map first released **8 months** after EQ

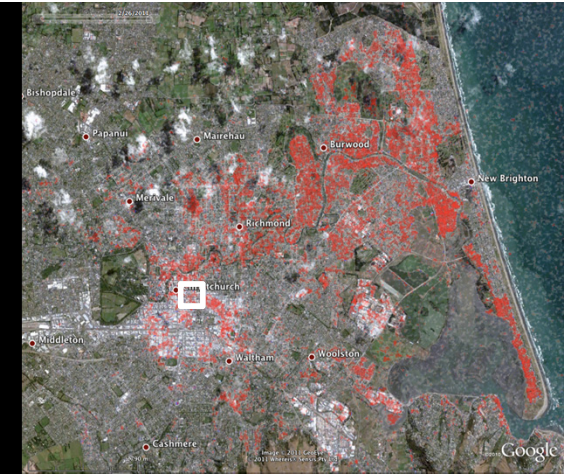


2011.10.28 version
Data provided by the New Zealand Government
<http://data.govt.nz>

Christchurch Cathedral



Christchurch Cathedral on the day of the earthquake (REX/The Telegraph)



Damage Proxy Map



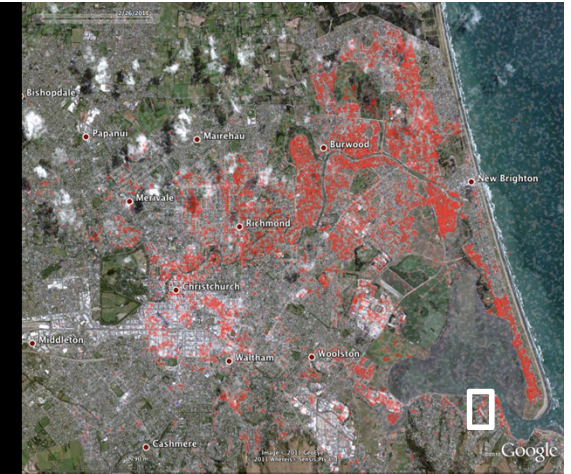
2010.09.03



2011.02.23



Cliff Collapse



Luxury homes teeter on the edge after huge landslides in Redcliffs, near Christchurch (Photo by Torsten Blackwood from AFP).



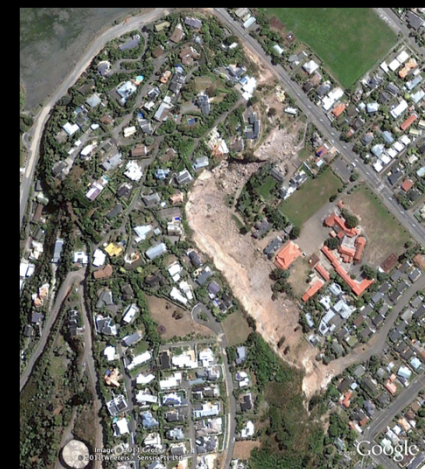
Damage Proxy Map



2010.09.03



2011.02.23



2011.02.26

EQ M6.3

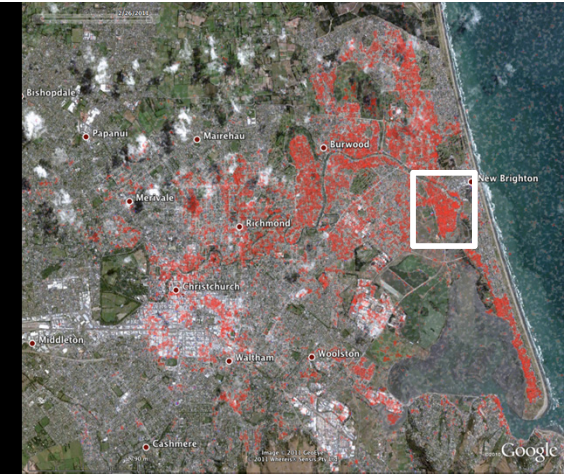
Liquefaction in Bexley



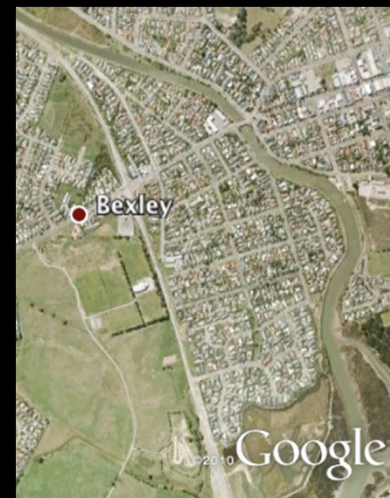
Cars stuck in the mud, Bexley
(Brett Phibbs/AFP/Getty Images)



Water Inundated Bexley (Mark Mitchell/New Zealand Herald/Associated Press)



Damage Proxy Map



2009.03.04



2011.02.23

Tohoku Earthquake

March 11, 2011

Magnitude 9.0

At least 15,822 people were killed

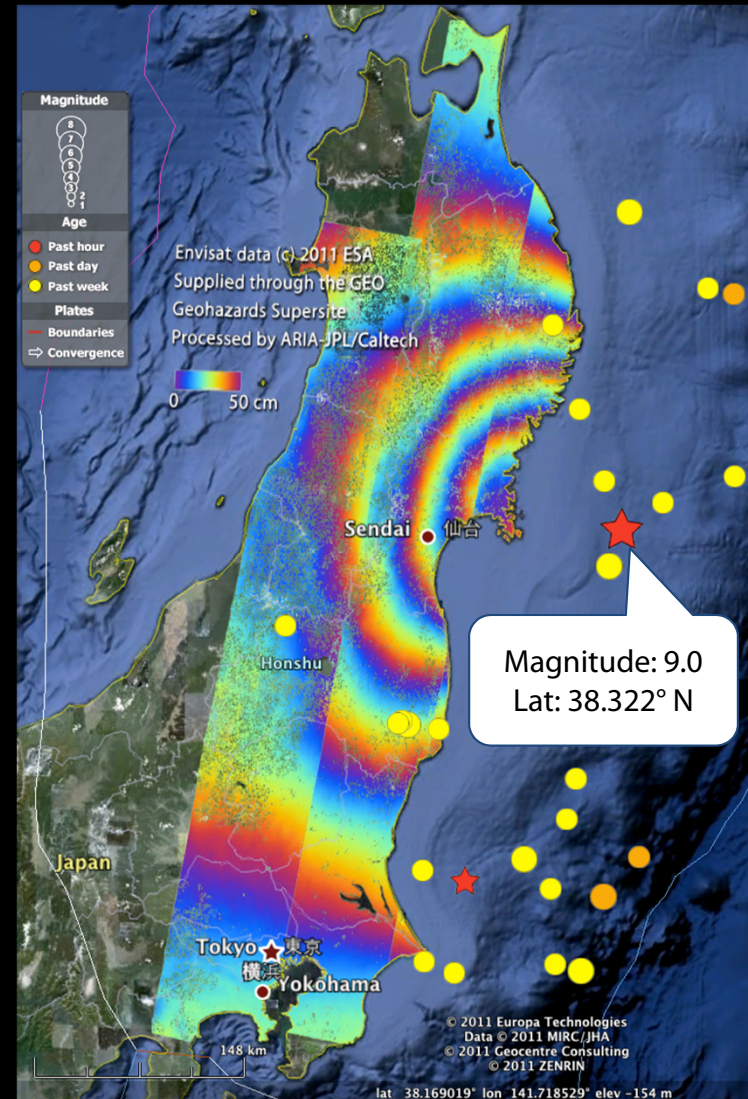
3,926 people missing

125,000 buildings damaged/destroyed

Estimated cost: US \$300 billion

Damage assessment by Japanese government under progress

Envisat (C-band) Interferogram:
One color cycle = 50 cm LOS disp.



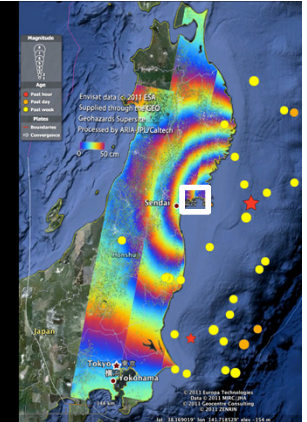
ARIA product, featured in NASA photo journal, ESA portal, and GEO supersite

Damage Proxy Map from Coherence Change and Amplitude Change

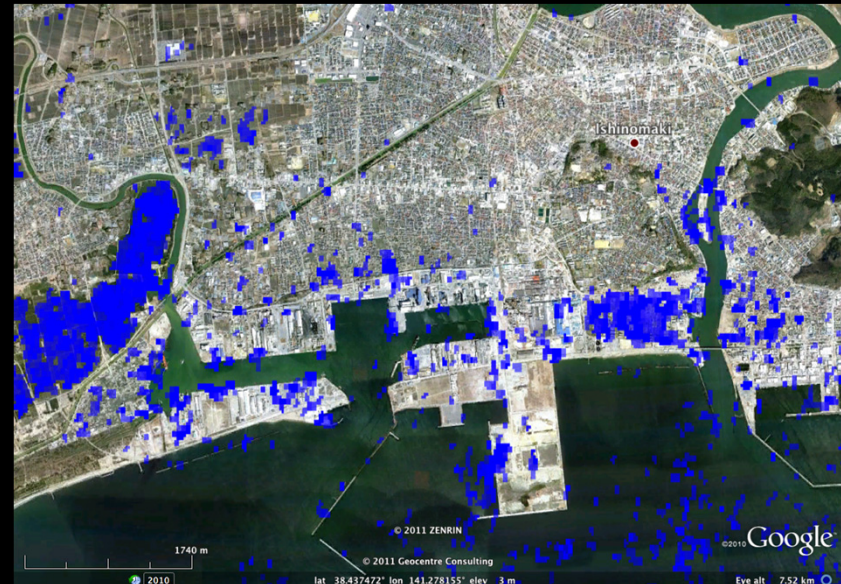
Ishinomaki, Japan

Envisat (ESA, C-band) ASAR

2011.01.31-2011.03.02-2011.04.01



Coherence change: Building damage due to tsunami waves



Amplitude change: Inundated areas as of 2011.04.01

Conclusions and Future Work

Future radar satellites will visit SoCal within a day after a disaster event. Data acquisition latency in 2015-2020 is 8~15 hours. Data transfer latency that often involves human/agency intervention far exceeds the data acquisition latency. → Need interagency cooperation to establish automatic pipeline for data transfer.

The algorithm is tested with ALOS PALSAR data of Pasadena, California. Quantitative quality assessment is being pursued: Meeting with Pasadena City Hall computer engineers for a complete list of demolition/construction project → 1. Estimate the probability of detection and probability of false alarm 2. Estimate the optimal threshold value.

The algorithm will be improved under a NASA fund (Program: Applications of Geodetic Imaging, PI: Sang-Ho Yun), utilizing temporal characteristics of coherence and be optimized for each type of data (UAVSAR, TerraSAR-X, COSMO-SkyMed, Sentinel-1a/b, US L-band SAR Mission*)

* Proposed Mission - Pre-decisional - for Planning and Discussion Purposes Only

